EVALUATION OF LEANING UNIT DESIGN WITH USE OF PAGE FLIP INFORMATION ANALYSIS

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ABSTRACT

In this paper, the authors attempted to evaluate design of leaning units with use of Learning Analytics technique on page flip information. Traditional formative assessment has been carried out by giving assignments and evaluating their results. However, the information that teacher can get from the evaluation is limited and coarse-grained. The authors set a research question that whether one can evaluate relation between learning objectives of learning units and the learners' actual activities in the units from page flip histories. The experimental result showed that the intensity of relation between the assignments and learning materials were different for each unit. Quantitatively, the correlation coefficients between "p-value of chi-square tests between range of page flip count and grade of assignment" and "proportion of number of questions in an assessment with reference page" was -0.889. With use of this relation, the authors attempted to evaluate design of units, and found out that the thing that may be critical to get high grade in an assignment of a certain unit was how many times they refer to their text book, though this assignment was designed for assessment of learners' skills to use or apply the learned knowledge. If teacher can get such suggestion as feedback, it is possible to utilize for formative assessment.

KEYWORDS

Learning Analytics, Formative Assessment, Learning Objective, Learning Log, Page Flip

1. INTRODUCTION

1.1 Digitization in Education and Learning Analytics

In the age of paper-based learning environment, learning records were limited in respects of both quantity and variety. It consisted of only results of exams, grades of assignments or course histories; even they were usually written with pencil or ink on paper. In 1990s, with the introduction of computers into schools, learning record data had been moved into machine-readable form. In 2000s, Learning Management System (LMS) had been spread, and many types of learning activity logs were collected. Finally, in 2010s, usage of laptop or tablet PCs has become common in even K-12 education. It enables to record or collect various fine-grained learning activity logs. It is notable that these modern logs contain client-side activities, e.g. page flip, process of answering, eye-track, voice and environmental sound, and GPS information. In the future, even physiological data like blood pressure, sweating or heartbeat will be treated as "learning activity logs".

Along with the trend on digitization in education, Learning Analytics (LA) has become a major area in learning science and learning technology research. Ferguson (2012) described a definition of Learning Analytics as follows: "Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs." Ferguson does not refer to "report to whom" in her definition of LA. However, some target to report can be assumed, for example learners, teachers, or schools, and the authors think their needs in LA depend on each target. For example, learners want to know their own grade or position in their class, while teachers want to know whether their lectures worked as they had intended.

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1.2 Learning Analytics and Formative Assessment

In this paper, the authors focus on utilizing LA for formative assessment, in other words, LA for teachers. Bloom (1971) described a definition of the formative assessment as follows: "the use of systematic evaluation in the process of curriculum construction, teaching and learning for the purpose of improving any of these three processes." This Bloom's definition of formative assessment is very similar to Ferguson's definition of LA, especially on its purpose.

Traditional formative assessment has been carried out by giving assignment or quiz and evaluating their results. However, assignment or quiz is not more than once a unit and therefore information for the teachers is limited and coarse-grained. Therefore, teachers observe their learners carefully to get further information. However, it is difficult to get what they did or said, much less what they thought or what they learned. In cognitive science area, there are many methods to estimate such cognitive information. These methods are able to give fine-grained information. However, it needs qualitative assessment and it is also heavy workload to carry out these assessment or observation in practice.

However, as mentioned in Section 1.1, fine granularity learning data has been recorded in machine-readable form. In LMS based environment, some kinds of LA are already at practical stage, and some LMSs have functions such as summary of login history/ course history/ grade, visualization of their week units, or recommendation of related courses. Educational applications also have had functions to visualize information of same kind. Some leading-edge LMSs or applications have functions such as evaluation of design of courses, units or learning materials by analyzing learning logs. That is, for example, to verify whether learners who take a certain course were target learners as expected, or to analyze the reason why many learners chose or wrote wrong answer in a certain problem.

One factor of the learning design that the authors have focused on is learning objective. As often said, learning objective of some units are acquisition of knowledge or theory while that of other units are application of them. In Japan, Ministry of Education, Culture, Sports, Science and Technology (MEXT) has been conducting the National Assessment of Academic Ability (NAAA) in mathematics and language for Grades 6 and 9 every year. According to OECD (2015), NAAA consists of two types of assessments: assessment on learner learning (subject knowledge; problem Type-A) and learner achievement (practical use of knowledge and skills; problem Type-B). Shirouzu (2015) mentioned that "problem Type-B" is roughly corresponding to TIMSS or PISA literacy problems respectively."

There are some researches or practice of utilizing learning data to assessment, and Ripley (2007) reported update on research, policy and practice, and the author of that paper called such assessment as "e-assessment".

1.3 Page Flip History

Among various data in Learning Analytics, the authors have focused on "page flip" log of learning materials. Page flip log or page transition log is the information when and in what order the learners flipped pages, and the authors called the sequence of page flip log "page flip history". This page flip history could not available from paper-based textbooks or other materials. In other words, teachers using paper-based textbooks conduct lessons on the assumption that their learners follow the teacher. However, if teachers use digital textbooks on client PCs, page flip history of each learner can be visualized by equipping function to collect page flip information.

There are many researches that focused on a kind of page flip history. Nicholas (2010) reported analysis of transactional logs obtained from the MyiLibrary platform regarding 127 UK universities. Also, in Japan, Kyushu University has carried out whole-university project to collect and analyze learning data from LMS (Moodle) and the e-book system (BookLooper) (Kyushu University Learning Analytics Center 2016). Objectives of their studies are as follows: (1) improving of learning materials, (2) analyzing learning patterns, (3) detecting students' comprehensive level, (4) predicting final grades, and (5) recommending e-books in accordance with personalization (Mouri 2016).

1.4 Research Question

The purpose of this research is to verify research question that we can evaluate design of learning units from page flip history of the units. Especially, the authors focused on the point whether we can evaluate relation between learning objectives of the learning units and the learners' actual activities in the units. If this relation can be visualized and evaluated, it leads to enable the quantitative formative assessment from fine granularity data with light workload.

2. METHODS

2.1 Target Courses, Units and Subjects

The authors set two target courses. Both courses were held in Sophia University, Japan, and one of the authors was in charge. Target courses, units, and the number of subjects are shown in Table 1.

Table 1. Information of Target Unit

Course	Unit ID	Unit	Date	Number of Subjects
Information Literacy	IL518	Journal search	May 18, 2015	71
	IL601	Numerical data	June 1, 2015	64
Learning Technology	LT519	Instructional Design	May 19, 2015	37
	LT526	Test and Feedback	May 26, 2015	34

The Information Literacy course was entry level for 1st year students, so contents were rather easy. In contrast, Learning Technology course was for 3rd year students, so contents were relatively difficult.

2.2 Data Acquisition Scheme

As previously reported (Horikoshi 2015), the authors focused on page transition of PowerPoint slide, because an author (Tamura) mainly uses PowerPoint in his lectures. And the other author of that paper (Yamazaki) developed the scheme and function to detect and transfer page flip logs automatically. This function is implemented in JavaScript, therefore the authors converted the original materials (Power Point files) into HTML and JPEG files, and added the JavaScript above. Page flip logs and other information are sent to Learning Record Store (LRS), when each subject changed pages. The items stored in LRS are as below:

- Actor: student's ID
- Verb: lunched/ experienced
- Page: page number
- Date: date and times

2.3 Procedure

In the target classes, the author (Tamura) held lectures as usual with use of these materials. Subjects access the proposing materials, and page flip logs were transferred into LRS, when each subject changed pages in the classes. Then, learners were given assignments.

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3. RESULT

3.1 Page Flip History and Page Flip Count

An example of page flip history is shown in Figure 1. In this figure, vertical axis shows slide page number and horizontal axis shows time (maximum of 90 minutes), and the thick line shows a history of a teacher while other thin lines show subjects'.

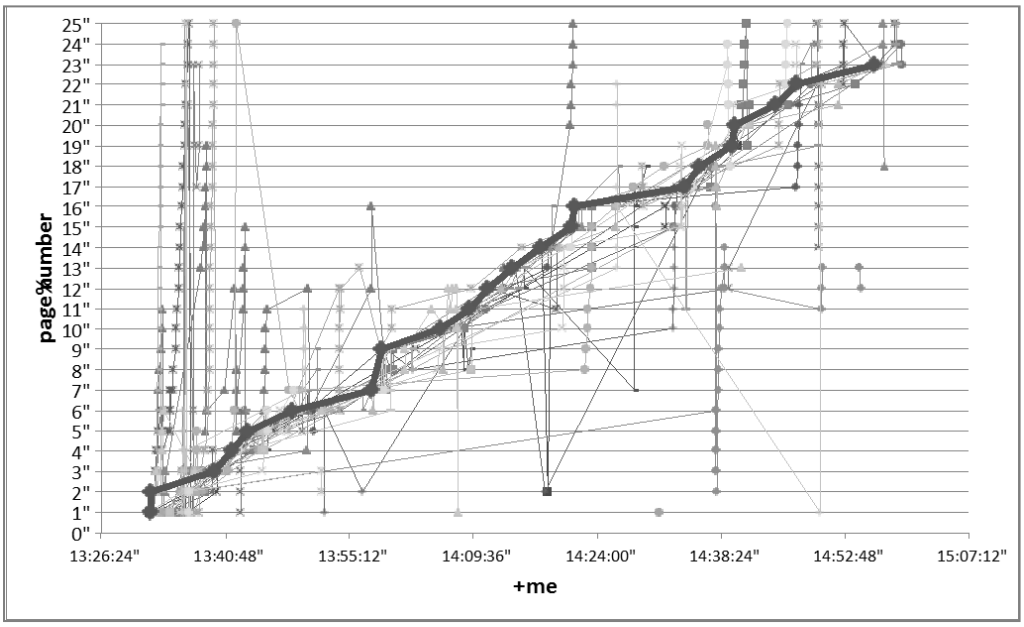

Figure 1. Example of Page flip history (LT526)

"Page flip count" is the number of page transition times. In this paper, the authors define the "page flip count" specially as follows: transition only from a certain page to other page. Some examples of fit/unfit case are as below:

- fit case: from page3 to page4
- unfit case: from page3 to page3 (click a link of current page)

3.2 Correlation between Page Flip Count and Grade

At the beginning of analysis, the authors determined the strength of a correlation between the page flip count and grade of assignment of each unit, for there might be general hypothesis that learners who refer to their text book many times are diligent, and they are able to get high grade at assignment of that unit. Scatter plot of the page flip count versus grade of assignment and correlation coefficients between them are shown in Table 2 and Figure 2.

Table 2. Correlation coefficients between page flip count and grade of assignment

Unit ID	Correlation coefficient	p-value
IL518	0.122	0.360
IL601	0.195	0.142
LT519	-0.142	0.409
LT526	-0.207	0.263

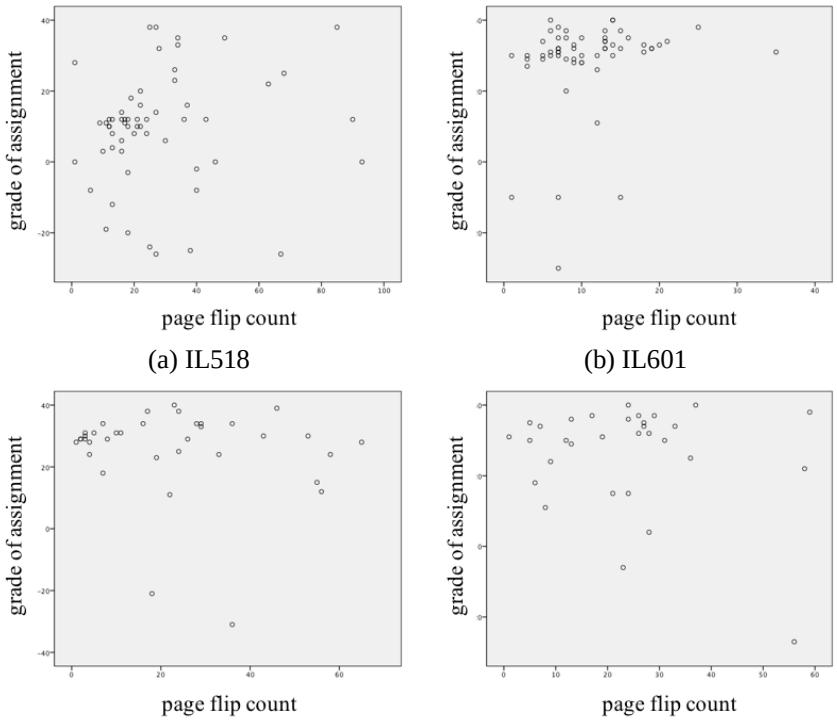

Figure 2. Scatter plot of page flip count vs. grade of assignment

As observed from Figure 2 and Table 2, there was no significant correlation between page flip count and grade of assignment. This result means even if learners referred to their text book many times, they cannot always get high grade at assignment. This is visually shown in Figure 3. Figure 3 shows page flip history of each learner in a unit (LT526), and the histories are ordered from upper left to lower right by their grades (history of the top left is the teacher's). Blank cells show learners who were absent from the class. For example, the learner in the 3rd cell from the right on the top raw is the second in grade of assessment while he or she was absent from the class.

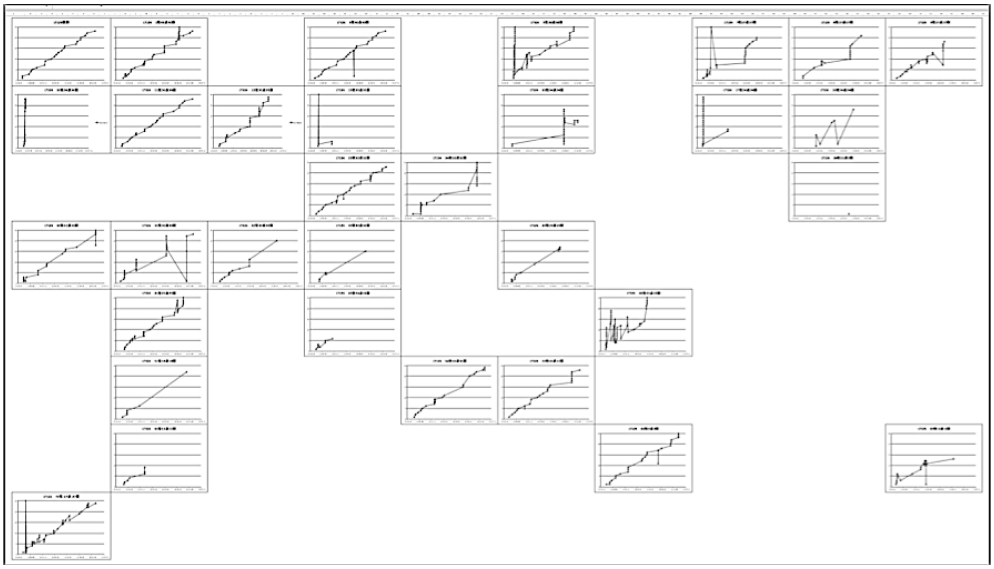

Figure 3. Page Flip history of each learner (ordered by grade, LT526)

3.3 Chi-Square Test between Range of Page Flip Count and Grade

As mentioned in Section 3.2, there was no significant correlation between page flip count and grade of assignment, therefore the authors verified whether there is a significant variation in grade by range of page flip count. The verification is performed using cross-tabulation and independent chi-squared test. For cross-tabulation, page flip count and learners' grade are divided into ranges as below:

Page flip count
- Range A: less than teacher's flip
- Range B: more than teacher's flip and less than twice of teacher's
- Range C: more than twice of teacher's

Grade of assignment
- Range 1: more than the first quartile
- Range 2: more than the median
- Range 3: more than the third quartile
- Range 4: less than the third quartile

The result of chi-square test of independence based on the cross-tabulation is shown in Table 3. Table 3 shows there is a significant variation in grade by range of page flip count in IL518 and IL601, but not in LT519 and LT526. This result possibly arose from difference between two courses (IL and LT). However, there are still difference even in same course, between IL518 and IL601 or between LT519 and LT526.

Table 3. Chi-Square Test between Range of Page Flip Count and Grade

Unit ID	χ^2	p-value
IL518	28.19	0.000
IL601	14.26	0.027
LT519	8.34	0.214
LT526	4.58	0.599

3.4 Relation between Assignment and Learning Materials

Based on the result in Section 3.3, the authors hypothesized that the intensity of relation between the assignments and learning materials are different for each unit, and the p-value of chi-square test in Section 3.3 reflects this intensity. As mentioned in Section 1.2, learning objective of some units are acquisition of knowledge or theory while learning objective of other units are application of them. For simplicity, the authors referred to the former units as Type-A, and the latter units as Type-B. The assignments of the units Type-A are designed for assessment whether learners acquired the knowledge lectured in the class, and assignments with such purpose may have reference pages in the learning materials. In contrast, the assignments of the units Type-B are designed for assessment of learners' skills to use or apply the learned knowledge, and assignments with such purpose may not have direct reference pages in the learning materials, or perhaps it may not be critical how many times they refer to their textbook to get high grade in assignment.

This hypothesis consists of following two elements; (a)Whether some questions have reference page and the others do not, and proportion of number of questions in an assessment with reference page differ from each unit, and (b) Whether there is correlation between p-value of chi-square tests between range of page flip count and grade of assignment and proportion of number of questions in an assessment with reference page.

First, the authors examined each assignment to verify (a), and evaluated proportion of number of questions in an assessment with reference page. The result of this evaluation is as follows: IL518 (20%), IL601 (10%), LT529 (5%), LT526 (0%). Proportion of number of questions in an assessment with reference page is given in parenthesis. This result demonstrated that the proportion of number of questions in an assessment with reference page differ from each unit, and this indicates that (a) is verified. Therefore, in second, the authors determined the correlation coefficients between the "p-value of chi-square tests between range of page flip count and grade of assignment" and the "proportion of number of questions in an assessment with reference page" to verify (b). Scatter plot of the p-value of chi-square tests versus the proportion is shown in Figure 4, and correlation coefficients between them was -0.889. It shows there is strong negative correlation between them, and this indicates that (b) is verified.

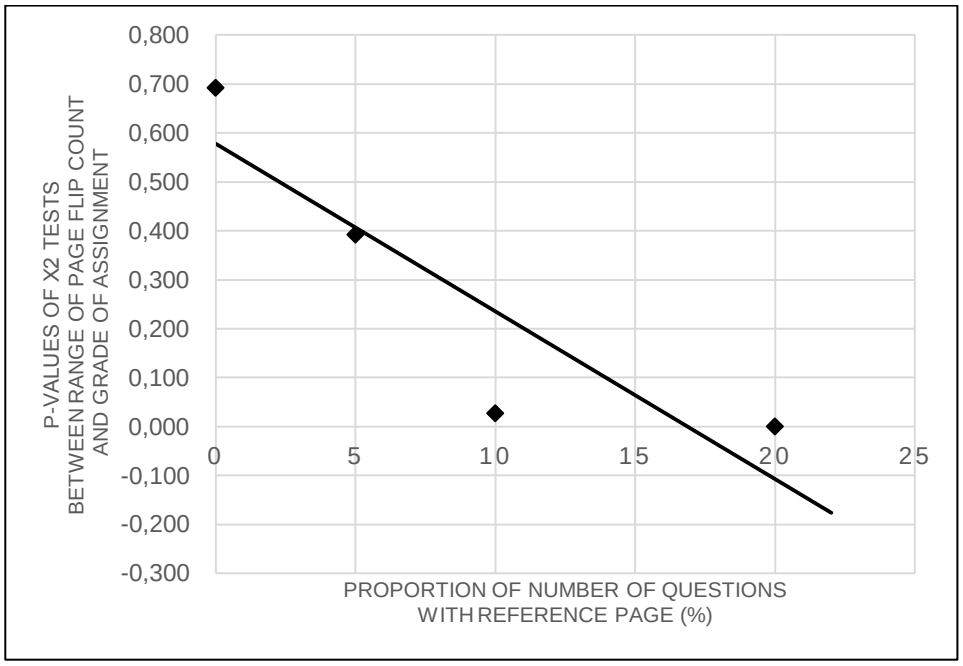

Figure 4. Scatter plot of "p-value of chi-square tests between range of page flip count and grade of assignment" and "proportion of number of questions in an assessment with reference page"

4. DISCUSSION

The result in Section 3.4 demonstrates that the intensity of relation between the assignments and learning materials are different for each unit. Also, Figure 6 and correlation coefficients in Section 3.4 show that larger proportion of number of questions with reference page the units have, more significant the p-values of chi-square tests are. That is, as mentioned in Section 3.4, intensity of relation between range of page flip count and grade of assignments reflects the intensity of relation between the assignment and learning material. Based on these results, it is suspected that it is possible to provide formative assessment from page flip history. In other words, it is possible to evaluate whether the lectures or assignments worked as teacher or designer intended from these two intensity of relation.

The intensity of relation between the assignment and learning material is quantitatively evaluated as the "proportion of number of questions in an assessment with reference page", and it may represent intention of learning design. By contrast, the intensity of relation between range of page flip count and grade of assignments is quantitatively evaluated as the "p-value of chi-square test between range of page flip count and grade of assignment", and it may represent how the lectures or assignments worked actually. If these two intensity of relation are comparable with each other, this may appear as negative correlation coefficients.

Therefore, in order to evaluate a certain unit from these correlation coefficients in terms of formative assessment, you should focus on whether a point of scatter plot shown in Figure 4 is on the regression line. For example, as observed from Figure 4, the point of IL601 is outliner. This shows that the "proportion of number of questions in an assessment with reference page" is small in this unit, though intensity of relation between range of page flip count and grade of assignments is strong. In this case, it is suggested that the thing that may be critical to get high grade in this assignment was how many times they refer to their text book, though an assignment of this unit was designed for assessment of learners' skills to use or apply the learned knowledge. If teacher can get this suggestion as feedback, it is possible to utilize for formative assessment; for example, a teacher improves his assignment as designed for assessment of learners' skills to use or apply the learned knowledge.

5. CONCLUSION AND FUTURE WORKS

The result of experiment demonstrated that the intensity of relation between the assignment and learning materials are different for each unit. Quantitatively, the correlation coefficients between p-value of $\chi 2$ tests versus proportion of number of questions in an assessment with reference page was -0.889. With use of this relation, the authors attempted evaluated design of learning units, and found out that an assignment of a certain unit was designed for assessment of learners' skills to use or apply the learned knowledge. However, the thing that may be critical to get high grade in this assignment was how many times they refer to their text book.

If teacher can get such suggestion as feedback, it is possible to utilize for formative assessment. It shows that the authors verified the hypothesis that we can evaluate design of unit from page flip history the unit, especially, the point whether we evaluate relation between learning objective of the unit and the learner's actual activity in the unit. The author believe that it leads to enable the quantitative formative assessment from fine granularity data with light workload in practice.

There are some future works related to this paper. In this paper, page flip log data was use as page flip counts. However, the original page flip log data contains sequence and time span. So, there is a possibility to analyze the data from temporal aspects.

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